GEOHERMAL DIRECT-HEAT UTILIZATION ASSISTANCE

Quarterly Progress Report

April - June 1993

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1.0 Project Summary: April - June 1993

- 1.1 Technical Assistance.** GHC staff provided assistance to 60 requests from 19 states. A breakdown of the requests according to application include: space and district heating (5), geothermal heat pumps (10), greenhouses (2), aquaculture (2), industrial (5), equipment (8), resources (9), electric power (3) and other (16).
- 1.2 R & D Activities.** Progress is reported on: 1) Evaluation of Lineshaft Turbine Pump Problems, 2) Geothermal District Heating Marketing Strategy, and 3) Greenhouse Peaking Analysis.
- 1.3 Technology Transfer.** Two presentations and one tour were conducted, and three technical papers were prepared. The GHC Quarterly Bulletin was sent to 1703 U.S. subscribers and to 298 foreign addresses. There were 31 volumes added to the library and information was disseminated to 19 requests.
- 1.4 Geothermal Progress Monitor.** Progress reports include: 1) USGS Forum on Mineral Resources, 2) Renewable Energy Tax Credits Not Working as Congress Intended, Geothermal Industry Tells House Panel, 3) Geothermal Drilling Ok'd Near Fields, 4) Newberry Pilot Project, and 5) Low-Temperature Geothermal Resources in Nevada.
- 1.5** GHC staff that worked on the project during third quarter included: P. Lienau 59%, G. Culver 95%, K. Rafferty 100%, Donna Gibson 62%, and J. Lund donated 40 hours to the project.

2.0 Technical Assistance

Geo-Heat Center staff provided technical assistance to the following during April - June 1993:

	<u>Name</u>	<u>Nature</u>
2.1	Alvin S. Hanzlik 15660C Miller Road Plano, IL 60545	GHP. Discussed geothermal heat pumps technology including groundwater and ground-coupled applications. Provided information on utility incentives. Two contacts in Illinois were provided to aid in design and installation of a GHP system (4-1-93).
2.2	Richard Parkes National Drying Machinery Co. 1290 Hormig Road Philadelphia, PA	Industrial. Discussed using geothermal energy for a food dryer. National Drying Machinery Co. is bidding on a geothermal food dryer to be installed somewhere in Nevada (secret). A 305°F geothermal resource is available for the project. Discussed corrosion, scaling, materials, heat exchangers, etc. Sent several chapters from the Direct Use Engineering and Design Guidebook (4-1-93).

- 2.3 Robin McGuire
846 Wright Avenue
Alliance, OH 44601
GHP. Provided information on comparisons of geothermal heat pumps with conventional systems and list of manufacturers. Discussed domestic water heating using a desuperheater vs demand-type heat pumps (4-2-93).
- 2.4 Rich Estabrook
BLM
Ukiah, CA
Resource. Discussed royalty billing considerations for a geothermal greenhouse operation at Lightning Dock, New Mexico. Requested information of flow meters and metering in general. Discussed problems and provided names of instrument manufacturers (4-3-93).
- 2.5 John Cogar
Lakeview, OR
Electric Power. Discussed status and condition of binary units of Jack Wood's project north of Lakeview. The discussion included operation (very short), refurbishing done by Barber-Nichols (heat exchangers and controls) and ORMAT (turbines) units. The units are to be auctioned off by the city (4-5-93).
- 2.6 Alfred Truesdell
700 Hermosa Way
Menlo Park, CA 94025
GHP. Requested international contacts on geothermal heat pumps. Provided: Lund University, Sweden; Institute of Geophysics, Switzerland; and Ontario Hydro, Canada (4-5-93).
- 2.7 Will Bunker
P.O. Box 9
Lake Village, AR 71653
Aquaculture. Discussed heat loss from ponds and provided spreadsheet on calculating pond heat loss. Also, discussed greenhouse heating using geothermal fluids (4-6-93).
- 2.8 Pat Lilly
EBASCO Environmental
Services, Inc.
Sacramento, CA
Equipment. Discussed metering of geothermal in general and problems due to scaling, corrosion and installation (4-7-93).
- 2.9 Doug Sherman
Parks & Recreation
Desert Hot Springs,
CA
Resources. Requested information on resources at parks and city golf courses for potential pool heating, etc. Discussed resources at the north and south parts of the town. Referred to Kristy Hunter and Tim Boardman of DOG for more specific information (4-9-93).
- 2.10 Jeff Henkleman
SEA Engineers
Sparks, NV
Resource. Requested thermal conductivity values for various types of soils, which were provided (4-12-93).
- 2.11 Kathy Manger
Meridian
Alexandria, VA
General. Assisted with a calculation of direct-use growth for a trend analysis (4-13-93).

- 2.12 Don Proteous
U.S. General
Accounting Office
San Francisco, CA
General. Working on an evaluation of geothermal direct-use and electric power in terms of resource base, sustainability, geothermal heat pumps, etc. Provided information on direct-use database and low-temperature resource assessment program (4-13-93).
- 2.13 Wayne Rasmussen
Coeur d'Alene, ID
Greenhouses. Looking for a greenhouse operation for a site in western Idaho on the Snake River, which has a spring fed pond, thermal spring at 90 gpm, Well-1 flows 100 gpm @ 130°F and Well-2 flows 80 gpm @ 85°F. Site consists of 40 acres with 20 acres suitable for development (4-13-93).
- 2.14 Elon Yurwit
Resource. Looking for a geothermal resource for a resort development. Earlier we had suggested Keough Hot Springs which apparently has some legal/personal problems. Discussed in general several hot springs in Utah and Colorado (4-15-93).
- 2.15 Stephanie Vujruch
Sportsman's Lodge
Box 305
Ennis, MT 59729
Resource. Faxed Thexton's well logs (956 ft) about 1 mile from site and log of well at Sportsman to 500 ft. Wanted to know if she should go ahead and deepen. Logs look similar; but, information on geology is sketchy. Referred to Bob Bergantino, MT Mines and Geology (4-15-93).
- 2.16 Steve Groseclose
Argonne Nat. Lab
Washington, D.C.
Resource. Requested number of direct-use injection wells. Read list over the phone including the larger heat pump injection wells the GHC knows of (4-15-93).
- 2.17 Jim Healey
AWS
Albany, NY
General. Working on a study of potential for electric power production and direct-use in upstate New York. Needs a list of candidates to do the work--a list of four companies with expertise in the geological area were supplied (4-19-93).
- 2.18 Doug Adkins
Consulting Engineer
K. Falls, OR
Resource. Discussed injection well disposal problems at Alturas, CA schools, including routes, amount of water, temperature, etc. City has requested Adkins engineers to look into possibility of using geothermal for heating city pools (4-20-93).
- 2.19 David Collar
15185 Vista Drive
Caldwell, ID 83605
Electric Power. Requested information on binary power plants, direct-heat applications and geothermal heat pumps, which was provided (4-20-93).

- 2.20 Manville B. Rose
14552 Mayfield Road
Huntsburg, OH 44046
GHP. Requested information on ground-coupled heat pumps since the current groundwater system does not supply enough flow. Provided a range of costs for vertical (\$700 - \$1000/ton) and horizontal (\$350 - \$500/ton), and literature on the types of systems (4-21-93).
- 2.21 Warren Nelson
RTD Hydro Project
Boise, ID
Electric Power. Discussed power generation locations. Building proprietary binary equipment of 1 - 2 MW to use low-temperature resources (4-23-93).
- 2.22 Ted Combis
1034 Leme Road
Redding, CA 96003
Space Heating. Building a light manufacturing plant in K. Falls. Wants to use geothermal if available. Discussed nearest wells which were about 4700 ft distance. Sent geologic information and information on wells. Property on Market Street, also being considered, has a good chance of hot water (4-26-93).
- 2.23 Bob Brennan
Bonanza, OR
GHP. Wants to install a groundwater heat pump. Discussed well (existing) and disposal options (4-29-93).
- 2.24 Michael S. Wilson
6361 Arapahoe Drive
Evergreen, CO 80439
General. Discussed 440°F well in the Piceance Basin of Colorado and referred to the Colorado Geological Survey. Also, discussed possibility of working in the geothermal industry and referred to several companies (4-29-93).
- 2.25 Kevin Taylor
1275 Taylor
Ogden, UT 84404
General. Discussed what the GHC does and renewable energy in general. Provided literature on geothermal direct-use (4-30-93).
- 2.26 Paul Hirsch
Argonne Nat. Lab
9700 S. Cass,
Bldg. 214
Argonne, IL 60439
GHP. Discussed geothermal heat pump technology and sent listing of GHP manufacturers. Referred to handbook by Steve Kavanaugh, University of Alabama (5-4-93).
- 2.27 Gary Thayer
LANL
Los Alamos, NM
Industrial. Discussed drying of coffee beans at Miravalles, El Salvador. A proposal for a pilot plant is being submitted (5-5-93).
- 2.28 Steve Rubin
NREL
1617 Cole Blvd.
Golden, CO 80401
GHP. Discussed geothermal heat pump technologies and solar assisted heat pumps. Provided manufacturers list for GHP (5-6-93).

- 2.29 Shawn Lockran
Clackamas County
Clackamas, OR
Resource. Requested information on wells near Government Camp. Discussed snow melt systems and well information on GHC files. Referred to Oregon Department of Geology and Mineral Industries (5-10-93).
- 2.30 Louie Templeton
Utility Supt.
City Hall
66 N. Lassen Street
Susanville, CA 96130
Equipment. Discussed and provided design for a geothermal depth/temperature well logger. Provided specs. on YSI 44014 thermistor and readout instrument (5-11-93).
- 2.31 Earl Kent
K. Falls, OR
Resource. Requested data on well at 719 Eldorado for inheritance, which was provided (5-11-93).
- 2.32 Frank Monastero
Commander
Naval Air Weapons
Station
Geothermal Program
Office
China Lake, CA 93555-6001
General. Provided "Geothermal Direct Use Engineering and Design Guidebook" for renewable and energy conservation possibilities at the facility. Also, sent information on the GHC technical assistance program (5-13-93).
- 2.33 Donald Yamada
U.S. General
Accounting Office
301 Howard Street
San Francisco, CA 94105
General. Spent 1.5 days at the GHC discussing the potential of geothermal district heating, low-temperature resource assessment and geothermal heat pumps. Provided tour of OIT, city, Liskey Farms and residence (5-18-93).
- 2.34 Peter Warnken
Decision Analysis
Corp.
1600 Spring Hill Road
Vienna, VA 22182
General. Discussed direct-heat applications of geothermal and temperature ranges. Provided literature on direct uses (5-20-93).
- 2.35 James V. Vantine
Consulting Geothermal
Geologist
97 Cottontail
Windsor, CA 95492
General. Discussed geothermal direct-use development, potential and provided back issues of the GHC Bulletin (5-20-93).
- 2.36 Don Combs
Commander
American Legion Post 8
K. Falls, OR
District Heating. Preliminary review for connection of the Legion building to the city's geothermal district heating system. Conversion of the existing system is estimated to cost \$11,000 and a share of the cost of extending the lines. Based on data from the gas company, weather normalized, annual costs for gas amount to \$765. Assuming a city geothermal rate of 50% of natural gas, the savings would amount to \$380/yr. This figure does not

compare favorably with the capital costs, which suggests it is not economically feasible to connect the building at this time (5-27-93).

- 2.37 Fr. Dreisbach
Sacred Heart Church
429 North 8th Street
K. Falls, OR 97601

District Heating. Preliminary review for connecting the Sacred Heart Church to the city's district heating system. The cost for converting the buildings (sanctuary, gym, parish hall) is estimated to be \$30,000 including engineering and contingency allowances. In addition, a fee would be assessed for connection to the extension line, estimated at \$8,400. Based on average gas heating costs of \$4,800/year and assuming a city geothermal rate of 50%, the resulting savings would be \$2,400/year. A 12% increase for natural gas is currently before the PUC (5-27-93).

- 2.38 Eric Womer
Wormser Scientific
Assoc.
66 Doral Farm Road
Stanford, CT 06902

GHP. Discussed groundwater heat pump systems for large buildings. Based on experience, three items are critical to successful applications: 1) drill and test wells prior to system design, 2) perform complete water chemistry analysis on well fluids, and 3) isolate groundwater from the building mechanical system with heat exchangers (5-28-93).

- 2.39 John Skaggs
229 Malabu Drive
Lexington, KY 40502

GHP. Discussed geothermal heat pump technologies, groundwater and ground-coupled systems, and costs. Provided a contact in Kentucky and sent literature and listing of manufacturers (5-28-93).

- 2.40 Kelly Mulville
33800 Highway 550
Durango, CO 81301

Greenhouses. Discussed cost of greenhouse heating equipment using 96°F water to heat a 20,000 ft² greenhouse with double plastic roof and single fiberglass sides. For four different inside temperatures ranging from 50 to 65°F, the cost ranged from \$1.80 to \$3.70/ft². Suggested a hybrid system be considered in which geothermal provides the base load and a fossil fuel such as propane provides peak load energy. The advantages are: 1) it can reduce the capital costs of the heating system, and 2) the fossil fuel peaking system can provide some emergency backups in the event of failure of the geothermal system (6-1-93).

- 2.41 Chuck O'Donnell
U.S. BLM
1800 Marguess Street
Las Cruces, NM 88005
Equipment. Reviewed draft specifications for the metering system of Burgett Floral, Lightning Dock KGRA, New Mexico. Comments included calculations methods, equipment requirements for flow meters, RTD temperature probes, calibration and maintenance, and how to monitor wells using a downhole heat exchanger (6-1-93).
- 2.43 Rob Colman
Frontier Aquadine
576 "B" Street
Santa Rosa, CA 95401
Industrial. Discussed low-temperature desalination equipment and proposed project in Colorado. Explained how the GHC could help through the technical assistance program (6-1-93).
- 2.42 Stephen M. Carnody
P.O. Box 724
Augusta, ME 04330
General. Requested information on renewable energy. Sent information and letter on geothermal direct uses, especially geothermal heat pumps (6-1-93).
- 2.44 Darrell Jackson
Yreka High School
Yreka, CA
Space Heating. Reviewed well logs for a geothermal heat pump system for the high school. Phoned well driller--checked with CA water resources, and Mines and Geology. New well is not producing as expected; but, no good geology available in the town to base recommendations on. Pump test report 350 gpm at 40 - 45 ft pumping level for 45 min.; then dropped to 150 ft in 15 min. and broke suction after 20 min. Produced only 120 gpm with 150 ft pump level, water "cloudy." Initially assumed cave in since cased only 48 ft; but, Darrell checked depth which was still at the original 200 ft. Must be boundary or taking water from limited gravels (6-2-93).
- 2.45 Elon Yurwit
Dreamlight Images
Inc.
932 N. LaBrea Avenue
Hollywood, CA 90038
Resort. Requested information on hot springs to purchase. Had questions about Maple Grove Springs, Idaho; Magic Springs, Nevada, and Jackson and Elkhorn Springs, Montana. Provided chemistry and other information over the phone (6-2-93).
- 2.46 Roger Peake
CEC, MS-43
1516 Ninth Street
Sacramento, CA 95814
Equipment. Discussed downhole heat exchangers--explained how they work, and where they will and will not work. The reasons they will probably not work at Alturas are: 1) deep wells--resistance to flow gets high and heat conduction through the casing on convection promoter short circuits the convection cell, 2) no convection promotion perforations, 3) high permeability and relatively high hydraulic gradient required, and 4) DHE

would work with a well bleed; however, more heat could be obtained using a plate heat exchanger with the same bleed flow (6-3-93).

2.47 Dean Day
City Engineer
Ely, NV

Pool. Investigating potential of using Cackawana Hot Springs for swimming pool --40 x 90 ft wood structure cover. Checked data--temperature 75 - 90°F at 240 gpm. Checked with Nevada Health Department--probably need to disinfect (chlorinate) pools and spas. Flow throughs can be used if drained and cleaned after each use. Spring temperature marginal for pool--suggested drill well and for improve springs. Checked with Nevada State Engineer Office--no wells within 2 miles. Rich Skivers, environmental health specialist in Ely, can help/advise on health requirements for pool. Sent all information that could be found, mostly from NBMG and Larry Garside (6-3-93).

2.48 Erik Berall
1025 S. Cloverdale
Avenue
Los Angeles, CA 90019

General. Requested information on geothermal direct uses. Provided publications listing, back issues of the GHC Bulletin and described the technical assistance program (6-4-93).

2.49 Scott Baker
Spice Island Farms
7318 Batavia Road
Dixon, CA 95620

Industrial. Discussed proposed drying plant development which included: well depth, flow and temperature, type and manufacturer of drying system, annual output and source of raw product, and finished product (6-7-93).

2.50 Doug Bell
John Curollo
Engineers
450 N. Wiget Lane
Walnut Creek, CA 94598

Resource. Requested resource information on Lightning Dock KGRA. Provided 1983 geology and geochemistry study. Discussed status of power company and direct heat (6-10-93).

2.51 Ray Grozell
Modoc Pump Co.
Cedarville, CA

Equipment. New well located approximately 5 miles north of Cedarville--135°F. Requested information on pipe for radiant heating. Provided information on temperature/pressure limits on the phone (6-9-93).

2.52 Ruben Castillo
WNC, D-C-1, 126899
P.O. Box 1260
Winnfield, LA
71483-1260

General. Requested information about GHC and back issues of the Bulletin. Discussed Center programs and sent publications request form (6-14-93).

- 2.53 Dimitri Stamatiou
3838 Rainbow Blvd.
Kansas City, KS 66103
Aquaculture. Requested cost analysis for aquaculture project in Greece. Provided names of two U.S. consultants who have had experience with aquaculture. Provided comments on U.S. example and on pond heat loss (6-16-93).
- 2.54 City of Susanville
Susanville, CA
Equipment. Profiled depth/temperature log of Richardson Well No. 1. Also, gathered information on and inspected failed pump out of Susan No. 1. Pump locked up after power failure--no lateral movement. Sending pump back to Hays Pump, Anderson, CA for inspection (6-17 & 18, 93).
- 2.55 Don Yamada
U.S. General
Accounting Office
San Francisco, CA
Industrial. Discussed exclusion of TEOR from the direct-use database. In most cases of the Powder River Basins of MT, ND and WY, water is injected at a lower temperature, then the in-situ reservoir; therefore, there is no thermal enhanced oil recovery. Provided status and updated table of U.S. direct use (6-23-93).
- 2.56 Rob Bloomquist
Bentley, NV
Equipment. Discussed for pump problems analysis using vibration analysis equipment. Can tell when problem is about to occur, but probably not reason (6-24-93).
- 2.57 City of Susanville
Susanville, CA
Equipment. Traveled to Anderson, CA--Hays Pump Co. to witness tear down of Susan No. 1 pump. No apparent reason for lockup? (6-28 & 29-93).
- 2.58 Frank Hall
11210 Wilson Road
Utica, OH 43080
GHP. Owns a 4000 ft² home in a rural setting and wants to install a geothermal heat pump. Discussed groundwater heat pumps using an existing well vs a ground-coupled system. Provided estimated costs and referred to Buckeye Power. Also, sent information on both groundwater and ground-coupled systems (6-29-93).
- 2.59 Lisa Powell
210 N. 6th Street
Grand Forks, ND 58203
General. Working on a research project on renewable energies and specifically geothermal direct use. Provided general information on direct use and some specific examples (6-29-93).
- 2.60 Elon Yurwit
932 N. LaBrea Avenue
Hollywood, CA 90038
Resort. Called to talk about Symes Hotel Hot Springs, MT. Thinking about purchasing the resort. Provided water chemistry and general geology. Discussed greenhouse heating methods and temperatures (6-30-93).

3.0 R & D Activities.

3.1 Evaluation of Lineshaft Vertical Turbine Pump Problems

The following is an interim report on specific pump failures for: 1) Susanville District Heating System Well - Susanville No. 1, 2) Modoc High School, Alturas, CA Well No. AL-1, and 3) College of Southern Idaho and Ross Colahan, Paisley, OR.

This project relies on real pumps in real applications rather than laboratory type testing. In this regard, it is similar to holes of opportunity in geological studies. One problem is to find pumps of opportunity. Requests will be sent to pump manufacturers, suppliers and users to obtain more data.

Susanville District Heating System Well - Susan #1

Pump

Ingersol Rand - 10 NK bowls - H impeller 7.28 inch diameter - 8 stage - 1 1/2 inch sst shaft. Bowls and impellers cast iron. 800 gpm @ 243 ft head. Pump bearings EPDM rubber.

Pump was set at 140 ft. Static water level 15 ft and pumping level at 800 gpm estimated at 100 ft. Pumping temperature 174°F. District heating system has never realized full build out, so pumping rate probably never exceeded 350 - 400 gpm. Variable frequency drive controls pumping rate to match requirements.

Column is enclosed lineshaft oil lubricated with 2 1/2 inch tube. 1 1/2 inch shaft with bronze bearings on 5 ft centers.

Symptoms

According to pump installer, this pump was "tight" at installation. Shaft was difficult to turn by hand and lateral difficult to adjust. Lateral was adjusted to top, then backed

off, according to manufacturer's specifications. Motor current was initially high, but reduced to normal after several hours run in.

This pump operated satisfactorily for approximately 18 months (exact dates of installation and removal are being confirmed). After a power failure in early June 1993, the pump could not be restarted. Drive motor stalled and lateral could not be adjusted either up or down and the drive shaft could not be turned with a pipe wrench.

Note that the pump had previously restarted after several power failures during its installed time.

A new (rebuilt) pump was installed using the same column, shaft and bearings. The column bearings reportedly showed very little wear.

On June 18, 1993, the pump was briefly inspected in the Tri-County Pump yard near Susanville. An antectodal history (above) was obtained from the owner Larry Cravey. The pump was subsequently shipped to Hays Pumps in Anderson, CA, for disassembly and inspection.

On June 29, 1993, the pump was disassembled at Hays Pumps with a Geo-Heat Center staff member witnessing. Prior to disassembly, the pump shaft could not be turned and there was no lateral movement.

Inspection Results

When the Center staff member arrived, the pump was on a pump stand with the tail (inlet) and head (outlet) sections removed and not apparent. Presumably, these had been reused in the installation of the replacement pump. The tail bearing area looked to be in new condition--scratching with a fingernail could not detect any wear in the bearing area. At the headshaft bearing location, there was slight detectable wear around approximately 120 degrees of the pump shaft. This later was dial indicated and found to be 0.004 inch.

Disassembly proceeded about normal. Exceptions were--initially the top impeller could not be driven off the collet. It was decided to try disassembly from the bottom up; but, the collet could not be driven up inside the impeller. Heat was used on the bottom impeller with no better results after a number of hits with the slider. At that point, it was noted that the top collet had loosened in the top impeller and was disassembled. Disassembly proceeded normally from top down. Each impeller and bowl was visually inspected for wear as disassembled. The third from bottom impeller was noted to have a crack in its hub and extending to the outer end of the vane, but did not extend to the skirt. There was no rotation or lateral movement until the second from bottom impeller was loosened from its collet.

Bowels and matching skirts were measured after disassembly. All clearances were 0.010 ± 0.001 - including #3 with the cracked hub.

Shaft run out was dial indicated at 0.002 - 0.003 except at discharge bearing noted above. Bearing wear areas were shiny, but could not be detected by fingernail. Rubber bearings appeared to be in the like new condition. Machining marks could be seen on both bowls and impellers indicating there had been no lateral wear. Bowls and impellers were shiny for about 5/16 inch indicating where impellers had been running; but, this was not detectable by fingernail or micrometer.

During disassembly, a black flaky material was noted in the bowls--probably iron sulfide--it broke down to a very fine powder when rubbed between fingers. Each bowl had about the amount that could be picked up by scraping with two fingers--less than 1/8 teaspoon--some in the bowl itself and some in the bowl/skirt running area.

Conclusions

None.

All normal and abnormal wearing surfaces were in new or near new condition. There were no indications of seizure. Hays pump engineers felt that the black flaky material may have settled into the 0.010 clearance between the impeller skirts and bowls, and bound the pump, similar to sand binding a well pump screen to remove it. Particles found in the bowl/skirt area were smaller than those in the bowl itself--perhaps crushed while driving impellers off the collet?

The reason for this pump seizure will probably never be known for sure.

No serial number could be found on the pump. Records of purchase and installation being checked.

Modoc High School - Alturas, CA - Well #AL 1

Pump

Worthington, BL 12, 11 stage, 9 impellers 5.81 in. trim, 2 impellers 5.13 in. trim, @ 1760 rpm, 80 gpm with 347 TDH. Enclosed lineshaft pressure oil lubricated. Pump setting 320 ft. Serial number C51591.

Total lateral 11/16 in. after machining extra 1/4 inch.

Bearing material specified was Bronze ASTM B271 Alloy 932 - Cu 83%, Sn 7%, Pb 7%, Zn 3% centrifugally cast. Bowls and impellers cast iron.

Worthington drawing, material and pattern information on file.

Pump installed by Modoc Pump Co., Cedarville, CA. Interview indicated no installation problems--no hang up, well straight, pump and column could be easily rotated by hand when at setting depth. Normal start up--no excessive current draw on motor. Novibrations noted; although, it is unclear what the rpm ranges were, Pump is run on variable frequency drive and has bypass back to well to provide minimum recommended flow through pump when entering system is calling for minimum heat.

Symptoms

Pump was installed in March 1990 and ran satisfactorily through remainder of school year. Pump was run intermittently to provide hot water for showers during summer. The following school year, the pump seemed ok; but, by January of 1992, flow at given rpm was notably reduced and in order to maintain heat for school, rpm was increased. By May, flow was significantly reduced and pump was "noisy." Pump was pulled in June 1992. Approximately 20 months of satisfactory service had been achieved.

Left to right bottom: Oil tube brg., top impeller, top bowl, and 2nd impeller.

Top bowl, 2nd impeller, 2nd bowl, 3rd impeller, 3rd bowl, and mis. bearing remains.

3rd bowl, 4th impeller, 4th bowl, and 5th impeller.

4th impeller, 4th bowl, 5th impeller, and 5th bowl.

5th impeller, 5th bowl, 6th impeller, and 6th bowl.

9th, 10th and 11th impellers and bowls.

Inspection

A Geo-Heat Center staff member was on-site for pump tear down. Results of the inspection are shown in the photos.

The lower bearing in the oil tube was badly worn--hour glass shaped. There were only bits and pieces of bowl bearings except for the tail bearing which was worn but still intact. Starting at the top, the first impeller skirt was worn completely away; 2nd, 3rd and 4th impeller skirts were worn but still attached; 5th and 6th skirts were completely gone; 7th worn but attached; 8th completely gone; and 9th, 10th and 11th skirts were there. The 11th or bottom impeller and bowl showed the least wear. Lateral had been correct as evidenced by no wear on top of impellers and machining marks visible on bottoms. An identification number was readable on the bottom impeller.

Impeller and bowl vanes appeared in as cast condition indicating no sand pumping cavitation or recirculation problems.

The stainless steel pump shaft was in surprisingly good condition. There was visible wear at the bearing areas; but, it was even indicating the shaft was straight. Apparently, the impellers were acting as bearings during the later stages of pump life.

Conclusions

Nothing specific. The alternating nature of wear suggests a critical speed problem. It's impossible to determine the initial cause. It is possible the rotating parts were initially out of balance; but, this is usually detected during pump testing at the manufacturer. However, if the manufacturer was not aware the pump would be operated on a variable frequency drive, it may not have been tested through the entire operating speed ranges. There is no record to confirm this one way or the other.

One of the bearings may have prematurely worn allowing vibration to start--which would be self perpetuating.

During a discussion of this pump with an ex-pump designer/trouble shooter for a major pump manufacturer, now a private pump consultant, it was noted that top bearing problems have been caused by insufficient oil tube tension either through lack of tension during initial installation or due to alternating on/off operation and the resulting thermal expansion.

The bearing material is higher in tin content and lower in zinc which should make it less susceptible to dezincification noted in some geothermal components.

College of Southern Idaho

Pump

American Turbine, Model 11 H 110, 3 stage 189 TDH @ 1760 rpm, pump setting 220 ft, 8 inch column, water lubricated, column bearings on 10 ft centers.

Pump bowls, impellers and bearings specified as zincless bronze due to poor experience with zinc alloy bronzes in valves and fittings. 1 3/16 stainless steel bowl shaft.

Pump variable frequency controlled specified 1200 gpm @ 189 ft TDH @ 1760 rpm. Well is artesian, but won't handle high loads on artesian. Pump tested at 50% speed--441 gpm with 20 ft pumping level. At 100% speed 1174 gpm, 11 psi at surface, 121 ft pumping level.

Maximum temperature 98°F. Water analysis in file.

Pump installed late September 1992, failed December 1993 with about 200 hours run time.

Symptoms

Pump vibrated during initial start up at 25 - 40% of full speed. Variable frequency control set to run through that speed range quickly and to block out continued operation at those speeds. Vibration not noticeable at 50% and above.

Pump slowly pumped less and less, vibration got worse and worse. Complete failure December 1993.

Inspection

Pump was not inspected by Geo-Heat.

Initial inspection at Funk Irrigation showed top bearings worn most tapering off to tail bearing. Bowls and impellers worn out, pump shaft broken. Column bearings ok.

Pump was shipped back to American Turbine for failure analysis.

Teleconference July 1, 1993, with Dan Buetner, CSI maintenance supervisor, reported pump had been inspected by American Turbine and an independent pump consultant. Both concluded problem was due to improper installation--an alignment problem. It has not been confirmed whether the pump was or was not test run at manufacturer.

Conclusions

This pump should never have been allowed to stay in hole after vibration was noted at initial start up.

Purchase pump from reputable pump dealer and be sure he understands proposed operating conditions.

3.2 Geothermal District Heating Marketing Strategy

The Geo-Heat Center has been assisting the city of Klamath Falls in marketing the city's geothermal district heating system to commercial building owners in the downtown core area. The marketing approach which eliminates heat exchangers, energy meters (expensive to install) and offers heat on a flat rate basis has been very successful.

The enclosed report describes the market strategy developed design to address the following major issues:

- Rates
- Customer retrofit costs
- Financing
- System reliability
- City creditability
- Manpower requirements

Other cities promoting geothermal district heating systems could possibly benefit from the approach taken by Klamath Falls.

3.3 Greenhouse Peaking Analysis

As a result of a technical assistance request from Colorado, an addition has been made to the previously developed GHS (Greenhouse Heating Systems) spreadsheet. The addition allows for the calculation of fuel use by a non-geothermal (propane, electric, fuel oil, etc.) peak heating system.

In the Colorado project, an individual was interested in developing a greenhouse using a very low temperature resource (98°F) in a very cold climate (Alamosa). In this particular case, it appeared that designing the geothermal system for the base load (approximately 60% of peak) and providing peak heating with a conventional fuel would be an economical design strategy. To optimize the design, it was necessary to calculate fuel consumption for a variety of cases.

Using input information including greenhouse heat loss, design temperatures, peaking fuel type, combustion efficiency, and percentage of design loss served by the geothermal and peak systems, the spreadsheet calculates the peaking fuel required on an annual

basis. The fuel consumption is separated into day and night categories to allow for night setback if used. Calculations employ bin types weather data.

GREENHOUSE PEAKING SPREADSHEET

5-20-93

Night Temp	55 F	% Design	0 %
Day Temp	70 F	Out Des T	9 F
Efficiency	300 %	Fuel Energ	3413 btu/____
UA	3240 btu/hr F	Geo Cap	0 btu/hr
Sunshine	0 %	Fuel Use	43317 ____/yr

Bin	9-16	Total	Night Load	Day Load	Night peak	Day Peak	Night Peak Fuel
62	219	551	0.00E+00	5.68E+06	0	25920	0.00E+00
57	212	658	0.00E+00	8.93E+06	0	42120	0.00E+00
52	227	783	5.40E+06	1.32E+07	9720	58320	5.28E+02
47	267	826	1.45E+07	1.99E+07	25920	74520	1.42E+03
42	311	931	2.61E+07	2.82E+07	42120	90720	2.55E+03
37	282	1044	4.44E+07	3.02E+07	58320	106920	4.34E+03
32	251	1132	6.57E+07	3.09E+07	74520	123120	6.41E+03
27	127	675	4.97E+07	1.77E+07	90720	139320	4.86E+03
22	57	352	3.15E+07	8.86E+06	106920	155520	3.08E+03
17	24	150	1.55E+07	4.12E+06	123120	171720	1.52E+03
12	13	82	9.61E+06	2.44E+06	139320	187920	9.39E+02
7	6	39	5.13E+06	1.22E+06	155520	204120	5.01E+02
2	2	17	2.58E+06	4.41E+05	171720	220320	2.52E+02
-3	0	6	1.13E+06	0.00E+00	187920	236520	1.10E+02
-8	0	2	4.08E+05	0.00E+00	204120	252720	3.99E+01
-13	0	0	0.00E+00	0.00E+00	220320	268920	0.00E+00
-18	0	0	0.00E+00	0.00E+00	236520	285120	0.00E+00
-23	0	0	0.00E+00	0.00E+00	252720	301320	0.00E+00
			2.72E+08	1.72E+08			26538

Notes:

1. assumes that the geothermal system can meet all loads during the 9 to 16 hour period.
2. All calculations made at the bin midpoint temperature.
3. Assumes that the geothermal system continues to run along with the backup system at low temperatures.

It is possible that during installation the portion of shaft sticking out above pump upper bearing was bent--by improper handling after uncrating or by initial lifting from ground to well by attaching to shaft head.

Ross Colahan, Paisley, OR

Pump

Worthington 8 in. OD 5 stage semi-open impellers. Pump was used and reportedly newly rebuilt when purchased--as is, where is. No data on model or serial numbers. Pump is used to pump irrigation water to pond for cooling. On/off operation. Temperature 234°F.

Symptoms

Reduced flow and noisy. No record of run hours or number of cycles.

Inspection

Second impeller collet had slipped allowing impeller to ride on bowl--impeller and bowl badly worn. Other impellers and bowls worn showing lack of lateral length or poor lateral adjustment. Shaft broken at slipped collet.

Ross Colahan pump 230 ft - 1 1/2 yrs operation, shaft broken at impeller locating snap ring.

Conclusions

Use keyed and screwed collets when pumping water this hot.

Assure proper lateral allowance. Ross is 85+ years old and others often start and stop pump. It seems probable pump was started, warmed up and lateral adjusted each time cooling pond was filled (about 7 times per summer).

Day	Peak	Geothermal
Fuel	Day	
5.54E+02	4.33E+01	
8.72E+02	4.19E+01	
1.29E+03	4.49E+01	
1.94E+03	5.28E+01	
2.76E+03	6.15E+01	
2.94E+03	5.57E+01	
3.02E+03	4.96E+01	
1.73E+03	2.51E+01	
8.66E+02	1.13E+01	
4.03E+02	4.74E+00	
2.39E+02	2.57E+00	
1.20E+02	1.19E+00	
4.30E+01	3.95E-01	
0.00E+00	0.00E+00	
0.00E+00	0.00E+00	
0.00E+00	0.00E+00	
0.00E+00	0.00E+00	
0.00E+00	0.00E+00	

16779 3.95E+02

4.0 Technology Transfer.

GHC staff provided the following outreach and information dissemination services during the third quarter:

4.1 Technical Papers, Presentations and Tours.

1. Technical Paper. Oregon Business Magazine--article on the city of Klamath Falls geothermal district heating system including savings, expansion and marketing strategy (5-6-93).
2. Tour and Discussion. Don Yamada, GAO, San Francisco--reviewed geothermal district heating, geothermal heat pumps and resource assessment program. Toured OIT and city district heating, residential system and Liskey Farms greenhouses and aquaculture facility (5-20-93).
3. Presentation. ASHRAE meeting, "Environmental Considerations for Geothermal Energy As A Source For District Heating" by Kevin Rafferty.

Abstract:

Geothermal energy currently provides a stable and environmentally attractive heat source for approximately 20 district heating (DH) systems in the United States. The use of this resource eliminates 100% of the conventional fuel consumption (and hence, the emissions) of the loads served by these systems. As a result, geothermal DH systems can rightfully claim the title of the most fuel efficient DH systems in operation today.

Costs for producing heat from a geothermal resource (including capitalization of the production facility and cost for pumping) amount to an average of \$1.00 per million Btu.

The major environmental challenge for geothermal system is proper management of the producing aquifer. Many systems are moving toward injection of the geothermal fluids to assure long term production.

4. Presentation. ASHRAE Technical Committee 6.8 on Geothermal Energy Utilization--handbook and geothermal heat pump terminology (6-29-93).
5. Technical Paper. Reviewed and commented on "Geothermal Heat Pump Systems" by Phillip M. Wright and Stefanie Colvin (6-21-93).
6. Technical Paper. Prepared technology transfer examples for DOE publication. Examples included: Yakima Detention Facility, San Bernardino Geothermal District Heating System, Klamath Falls Geothermal District Heating System, Modoc High School, and Newcastle Geothermal System (Howard Ross, UURI).

- 4.2   GHC Quarterly Bulletin. Bulletin Vol. 14, No. 4 featured thermal springs in the U.S. and was mailed to 1703 U.S. subscribers and 298 foreign.

Plans for Bulletin Vol. 15, No. 1 include progress and development of Alturas geothermal system, Klamath Falls marketing strategy, resource assessment program, ancient uses of geothermal energy and the pipeline.

- 4.3   Geothermal Library. Thirty one volumes were added to the library during the third quarter. Work continued with the computerized library system with 663 entries of the library in the program.

- 4.4   Information Dissemination. The GHC provided the following with publications:

<u>Name</u>	<u>No. Publications</u>	<u>Nature</u>
<u>4/5/93</u>		
Robin McGuire Alliance, OH 44601	3	GHP
<u>4/13/93</u>		
Antonio Nevcs Trota S. Miguel - Acores, Portugal	6	GDH
<u>4/19/93</u>		
Benny Teale Dalles, OR 97338	3	GHP
David Wheeler Glenshaw, PA 15116	3	GHP
<u>4/20/93</u>		
David Collar Caldwell, ID 83605	7	Greenhouses
<u>4/21/93</u>		
Manville B. Rose Huntsburg, OH 44046	3	GHP
<u>4/22/93</u>		
Marita Kunkel Klamath Falls, OR 97601	3	GHP
<u>4/23/93</u>		
David Mead Ridgecrest, CA 93555	3	Other

4/27/93

Bob Carr
Holt's Summit, MO 65043

3

GHP

4/29/93

Bill Richardson
Beaverton, OR 97005-4421

6

Other

4/30/93

Jeff Sims
Sisters, OR 97759

3

GHP

Richard L. Williams
Pleasantville, NJ 08232-
4051

3

Other

5/4/93

Gladys J. Hooper
Washington, D.C. 20585

4

Other

5/10/93

Rebecca Christie
Olympia, WA 98504-7007

31

Greenhouses
Aqua
Other

5/11/93

Steve Rubin
Golden, CO 80401

9

GHP
Greenhouses
GDH

6/15/93

Joe La Fleur
Springfield, OR 97448

3

Other

6/16/93

Germelino F. Abito
Diliman, Quezon City,
Philippines

5

GHP

6/17/93

Bill Marci
Fort Collins, CO

3

Other

6/29/93

Frank Hall
Utica, OH 43080

3

GHP

5.0 Geothermal Progress Monitor

Meeting Announcement

USGS Forum on Mineral Resources

U.S. Geological Survey, 9th V.E. McKelvey Forum on Mineral Resources, February 22-25, 1994, Tucson Convention Center, Tucson, Arizona. Contact: Warren C. Day, U.S. Geological Survey, Box 25046, MS 905, Denver Federal Center, Denver, Colorado 80025, (303) 236-5568, FAX (303) 236-5603.

The forum will feature:

- Geology and mineral deposit studies of the southwestern U.S. and Latin America
- Mineral resource assessments and land use planning
- Minerals resource-related environmental studies
- Field trips in southeastern Arizona

General

Renewable Energy Tax Credits Not Working As Congress Intended, Geothermal Industry Tells House Panel

Thomas C. Hinrichs, President of the Geothermal Resources Association, told a House Ways and Means Subcommittee that the 10 percent tax credit for investment in solar and geothermal development--recently made permanent by Congress--isn't sparking investment because the credit is presently not allowed to be used against the Alternative Minimum Tax, or AMT.

Because of relatively higher initial costs, the AMT "is almost always triggered in the case of companies involved in geothermal development, and therefore, the geothermal tax credit is not available to do the job Congress intended it to do," Hinrichs told the panel.

"We strongly urge the Subcommittee and the Congress to support the full utilization of the energy tax credits against the AMT," he said.

Hinrichs, a Vice President of Magma Power Company of San Diego, praised the tax credit as "the single most effective federal program to promote renewable energy, stimulate investments and enable the technology to develop and improve."

"If the inability to apply the tax credit against the AMT was corrected by legislation, it would result in lower renewable energy prices being put forward in the bidding process" and "will enable renewable projects to compete with conventional fossil fuels in the bidding for new utility projects," Hinrichs testified.

"Such successful bidding will result in the twin national benefits of energy independence and environmental enhancement," he added.

Hinrichs noted that "ironically, twice in the last three years the oil and gas industries have received relief from the AMT in tax legislation. Coupled with other tax breaks enjoyed by the oil and gas industries, renewables remain some distance from reaching the proverbial 'level playing field'."

Hinrichs said the legislation introduced by U.S. Rep. Jim McDermott (D-Washington) (H.R. 2026) to allow the tax credits to apply against up to 25 percent of the AMT "is a fine start." But he stressed that "full utilization is the catalyst needed to spur renewable development."

He underscored the tremendous potential geothermal energy has for helping power America with clean, renewable and domestic sources of energy.

"Geothermal energy is environmentally benign, a fact which is of particular importance in an era of global warming stemming from excessive carbon emissions and air pollution caused by other harmful pollutants being emitted into the atmosphere," Hinrichs said.

The Geothermal Resources Association is comprised of 15 geothermal energy companies which operate geothermal energy facilities producing a total of approximately 2,800 megawatts of clean power. A 100-megawatt power plant can support the energy needs of a community of 100,000, he noted. (Source: Geothermal Resources Association)

Oregon

Geothermal Drilling Ok'd Near Fields

A government appeals panel has authorized Anadarko Petroleum Corp. to drill more geothermal test wells this fall near an eastern Oregon high desert lake that is the only home of a tiny endangered fish.

Barring further appeals, Anadarko hopes to drill two new exploratory wells and deepen an existing one after a summer moratorium expires at the end of August, Patrick A. Smith, project landman for Anadarko, said Friday from Houston.

Smith said the site is the most promising for commercial development of geothermal energy in the northwest. A coalition of environmental groups had demanded the U.S. Bureau of Land Management do a complete environmental impact statement examining the possibility of developing a commercial power plant at the site, located outside the town of Fields in Harney County. (Source: Herald & News)

Newberry Geothermal Pilot Project

CE Exploration Company (CEE), the project's proponent, is the Oregon-based subsidiary of California Energy Company, which is one of the country's largest independent producers of geothermal energy and now has six operating geothermal facilities in the western United States. Eugene Water & Electric Board (EWEB), co-proponent of the proposal, is Oregon's largest municipally-owned electric utility. In its 80 years of operation, it has developed a variety of small-scale, renewable power resources.

The proposal from CEE and EWEB is to drill a series of exploration wells to depths of 6,000 to 10,000 ft in order to test the availability of geothermal resources. They would need to find and be able to produce water at temperatures in excess of 400 degrees Fahrenheit in order to proceed with development. Assuming the geothermal resource is adequate, and also assuming that this pilot project is approved and successfully implemented, there is the potential for further expansion of 100 MW. However, further environmental analysis with additional public participation would be required before a decision could be made to approve any expansion or additional development.

The proposed power plant would require up to 10 production wells and three injection wells located within three miles of the plant site. Two or more of these production wells would be located on the same production well pad (see the drawing on the right below). The equipment on those pads would include water-steam separators, a large fluid holding pond (sump), and the insulated pipelines leading off to the power plant. CEE proposes to use a "flash technology" power plant with a condensing steam turbine and wet cooling tower. The generator and supporting equipment would be housed in a steel building with the cooling tower as a separate structure (see the drawing on the left above).

If the Pilot Project is approved, which could be in spring 1994, construction of the power production facilities could begin shortly thereafter. From the time construction begins, it would take 16 months or more before electricity is produced. (Source: Deschutes National Forest)

Nevada

Low-Temperature Geothermal Resources in Nevada

The U.S. Department of Energy began a new geothermal energy program in Fiscal Year 1991. The objective of the program is to promote accelerated development of low- and moderate-temperature geothermal resources, and thus to offset fossil fuel use and improve the environment. The program has several components: collection of geothermal resource data, development of exploration techniques, technical assistance to potential geothermal developers, and evaluation of geothermal heat pump applications and use. An important aspect of several of the components is the evaluation of low- and moderate-temperature geothermal resources, especially in the western United States. Participants in the program include the Geo-Heat Center at the Oregon Institute of Technology (Klamath Falls), the University of Utah Research Institute, the Idaho Water Resources Research Institute (University of Idaho, Moscow), and agencies of state governments in most of the western states.

The Nevada Bureau of Mines and Geology (NBMG) has been selected as the agency in Nevada to participate in this geothermal program. NBMG will prepare an up-to-date inventory of the state's low- and moderate-temperature geothermal resources (from 10°C above mean annual temperature to 150°C), and in cooperation with the Geo-Heat Center, analyze which of these resources are near population centers and thus more likely for development. This inventory will make use of the considerable geothermal resource data collected at NBMG in the late 1970s and of new data from published and unpublished sources. Water chemistry data are available for many thermal springs and wells, and will be made a part of the database for the project. A few new analyses of thermal waters are planned as well. The project will utilize the extensive GIS (Geographic Information Systems) capabilities available at NBMG to tabulate exact locations (map coordinates--for example, longitude and latitude) of all known thermal springs and wells.

A very important part of the data collection process is the identification of geothermal areas or sites which are relatively unknown or have not been previously described in published or otherwise readily available reports. Such sites would include warm or hot springs not shown on topographical maps or described in water resource reports, and areas of thermal groundwater encountered during drilling in areas not known to have geothermal resources. Additionally, NBMG needs more information on present uses of Nevada geothermal resources. Anyone who has information on new Nevada geothermal sites or uses should contact me at NBMG (702-784-6691). (Source: Nevada Bureau of Mines and Geology)